

Course Title: Control Systems Engineering  
Date: Nov., 22<sup>nd</sup>, 2014Course Code: CCE3115  
Allowed time: 75 MinutesYear: 3<sup>rd</sup> Comp.  
No. of Pages: (1)

**Remarks:** You must show all of your work -- partial credit may be given to partially correct answers, while answers with no justification may not receive full points. Please attempt all questions.

**Note:** There are extra 2 marks that can be used elsewhere to compensate for any loss of marks but the total marks will not exceed 30.

**Attempt all the following:-**

In airports, conveyor belts are used to transport both humans and bags. We will study the velocity control for such a conveyor belt. A model for the relation  $G_1(s)$  between the control input  $u(t)$  and the velocity  $y(t)$  is given by:

$$G_1(s) = \frac{1}{(s + 0.5)(s + 2)(s + 5)}$$

Suppose that the total block diagram of the conveyor belts system is as shown in Fig. 1.

- Draw the root locus for the open-loop transfer function to show how the closed-loop system poles changes as  $K$  varies from 0 to  $\infty$ . **(14 Marks)**
- From the root locus, determine the value of gain  $K$  for critically damped response (i.e. damping ratio is equal to unity). **(3 Marks)**
- Given the value of  $K = 15$ , draw the bode diagrams for the open-loop transfer function of the system. **(9 Marks)**
- From the bode diagrams, determine the Gain Margin  $GM$ , Phase Margin  $PM$ , the phase crossover frequency  $\omega_{pc}$ , and the gain crossover frequency  $\omega_{gc}$ . **(4 Marks)**
- Based on the results of part "d", Is the system stable? **(2 Marks)**

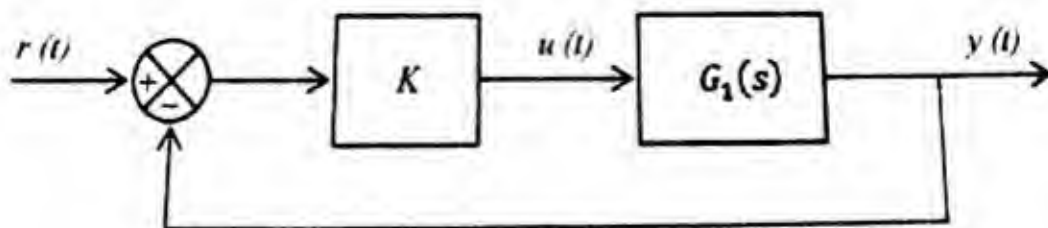


Fig. 1: Block diagram of conveyor belts system